

02-15-00

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UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)*(Only for new nonprovisional applications under 37 CFR 1.53(b))*Docket No.
ATK20582

Total Pages in this Submission

31

TO THE ASSISTANT COMMISSIONER FOR PATENTSBox Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

MULTIPLE PULSE CARTRIDGE IGNITION SYSTEM

and invented by:

Andrew B. Crickenberger and
Saleem L. GhaziIf a **CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 12 pages and including the following:
 - a. ☒ Descriptive Title of the Invention
 - b. ☐ Cross References to Related Applications *(if applicable)*
 - c. ☒ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
 - d. ☐ Reference to Microfiche Appendix *(if applicable)*
 - e. ☒ Background of the Invention
 - f. ☒ Brief Summary of the Invention
 - g. ☒ Brief Description of the Drawings *(if drawings filed)*
 - h. ☒ Detailed Description
 - i. ☒ Claim(s) as Classified Below
 - j. ☒ Abstract of the Disclosure

UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

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Application Elements (Continued)

3. ☒ Drawing(s) (when necessary as prescribed by 35 USC 113)
- a. ☐ Formal Number of Sheets _____
- b. ☒ Informal Number of Sheets 5
4. ☒ Oath or Declaration
- a. ☒ Newly executed (original or copy) ☐ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional application only)
- c. ☒ With Power of Attorney ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application,
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (usable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied
under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby
incorporated by reference therein.
6. ☐ Computer Program in Microfiche (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all must be included)
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy (identical to computer copy)
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(B) Statement (when there is an assignee)
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☒ Certificate of Mailing

☐ First Class ☒ Express Mail (Specify Label No.): EJ627432615US

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Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)

16. ☐ Additional Enclosures (please identify below):

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	20	- 20 =	0	x \$18.00	\$0.00
Indep. Claims	3	- 3 =	0	x \$78.00	\$0.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$690.00
OTHER FEE (specify purpose) Recording fee for Assignment					\$40.00
TOTAL FILING FEE					\$730.00

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Signature

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Dated: Feb. 14, 2000

*Alliant Techsystems Inc. Deposit Account
cc: Ms. Debbie Ledbeter, Alliant Techsystems Inc.

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Serial No.

Filing Date

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Group Art Unit

Invention:

MULTIPLE PULSE CARTRIDGE IGNITION SYSTEMjc525 U.S. PTO
09/30/524
02/14/00

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(Identify type of correspondence)

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MULTIPLE PULSE CARTRIDGE IGNITION SYSTEM

U.S. Government Rights

The U.S. Government has interests in this invention pursuant to Contract #DAAA21-87-C-0160 awarded by the Department of the Army.

10

Field of the Invention

The present invention is in the field of cartridge ignition systems and, more particularly, relates to an electronically controlled dual event or multi-pulse ignitor which can sense the temperature of the cartridge and adjust the ignition for a cartridge.

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Background of the Invention

One of the most important design variables in ammunition development is the performance of a cartridge over the operating temperature range. This performance is currently limited by the operating pressure at hot temperatures.

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Attempts to improve cartridge performance over a range of temperatures have typically relied on mechanical devices and propellant innovations. Propellant design, for example, has long focused on chemically creating a propellant to reduce performance differences over temperature. A mechanical design which has been explored uses control tube concepts to modify the initial travel of the projectile as a function of temperature using material thermal expansion or bimetallic strips.

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In contrast, the instant invention provides an ignition system known as a Smart Cartridge Ignition System, described hereinbelow, that controls the performance of a cartridge so that it is substantially invariant over ambient and cold temperature ranges.

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Summary of the Invention

According to the present invention, an electronically controlled multi-pulse ignitor is provided for a cartridge used to launch a projectile. An electronics module is programmed with a temperature performance profile for the cartridge. A temperature

sensor is coupled to supply current cartridge temperature data to the electronics module. A first event ignitor is coupled to the electronics module for initiating a ballistic cycle upon command from the electronics module. A translation mechanism, including a first charge coupled to the first event ignitor, moves the projectile forward to increase the free volume in the cartridge. A second event ignitor, coupled to receive a second event ignition signal from the electronics module, ignites the main propellant charge on receiving the second event ignition signal from the electronics module, wherein the timing of ignition of the second event ignitor is determined by the temperature performance profile and the current cartridge temperature data.

Brief Description of the Drawings

Figure 1A schematically shows a block diagram for one example of an electronically controlled multi-pulse ignitor system constructed in accordance with the present invention.

Figure 1B illustrates a process flow diagram for one example of an electronically controlled multi-pulse ignitor system algorithm constructed in accordance with the present invention.

Figure 2 and Figure 2A show a partially cut-away view of one example of a cartridge including an electronically controlled multi-pulse ignitor system constructed in accordance with the present invention.

Figure 3 schematically shows a view of an example of a cartridge system constructed in accordance with the present invention in an initial cartridge configuration.

Figure 4 schematically shows an example of a cartridge system constructed in accordance with the present invention in a translational cartridge configuration.

Figure 5 schematically shows a view of one example of a cartridge system constructed in accordance with the present invention in a cartridge configuration after main charge ignition.

Figure 6 graphically shows a comparison of one example of performance of a cartridge system constructed in accordance with the present invention against a conventionally ignited cartridge.

Detailed Description
of the Preferred Embodiment

Referring now to Figure 1A, a block diagram for one example of an electronically controlled multi-pulse ignitor system constructed in accordance with the present invention is shown. The system comprises a temperature sensor 16, a pressure sensor 105, a movement sensor 80, an electronics module 9, a first initiator 61 and a second initiator 70. Depending upon the cartridge system being ignited, a firing pulse will be generated either by an electronic firing pulse 5 in the case of an electronically fired cartridge, or a percussive firing pulse 6, in the case of a percussion fired cartridge. Electronics module 9 comprises a temperature profile memory 11 and an algorithm 10. Electronics module 9 includes electronics suitable for processing data and executing algorithm 10. It is contemplated herein that the novel process be constructed, and has been so constructed by the inventors, using standard electronics. Other useful embodiments may be constructed using digital circuitry and/or programmable computer, application specific integrated circuits, or microprocessor devices, components or equivalents using well known design principles.

Temperature profile memory 11 stores a temperature and event delay performance profile for a given cartridge. The temperature profile may be empirically derived from temperature and performance data for a cartridge using standard profiling techniques. The electronics module controls the first initiator 61 and the second initiator 70 by processing temperature data from the temperature sensor 16, pressure sensor 105 and movement sensor 80 with the temperature profile information as discussed in detail below with reference to the figures.

Referring now to Figure 1B, a process flow diagram for an electronically controlled multi-pulse ignitor system constructed in accordance with the present invention is shown. The process flow diagram shows one example of an algorithm 10. The algorithm 10 is initiated by the receipt of a firing pulse at event 12. The firing pulse is transmitted to a second event, fire primer event 14, where the first initiator is fired. The fire primer event 14 provides a signal to a decision event 18 for determining an appropriate delay. The decision event 18 receives current temperature data from temperature sensor 16 within the cartridge system. Decision event 18 determines an

appropriate delay by comparing the current temperature data with the stored cartridge temperature profile information, and it sends a count down period to event timer 20. Event timer 20 counts down amount of time determined at event 18 before firing the second ignitor.

5 During the countdown period, a second decision event 26 decides whether or not it is safe to fire the second ignitor. The safe determination is made using a first safety signal 22 from either the pressure sensor 105 and/or a second movement safety signal 24 from the movement sensor 80. If the pressure sensor 105 is activated, the first safety signal 22 is positive, allowing firing. Similarly, if movement is detected from the movement sensor
10 80, the second safety signal 24 is positive for allowing firing. In one embodiment, if either the pressure sensor activated event 22 or the movement sensor activated event 24 is negative, the safe to fire decision 26 transmits an abort signal to abort firing at event 28. If both the pressure sensor activated event 22 and the movement sensor activated event 24 are positive, the safe to fire decision 26 transmits a firing signal to fire the second ignitor
15 at event 30.

Referring now to Figure 2 and Figure 2A, a partially cut-away view of one example of a cartridge including an electronically controlled multi-pulse ignitor system constructed in accordance with the present invention is shown. It will be understood that the configuration shown herein is by way of example and that the invention is not so
20 limited. A projectile 50 includes a cartridge 58 wherein an ignition system 60 is located.

Referring now particularly to Figure 2A, an expanded, more detailed, schematic view of the cartridge 58 and ignition system 60 is shown. The ignition system 60 includes a first initiator 61, an electronics module 9, the second initiator 70 and a main charge ignition 67. The first initiator 61 includes an ignitor tube translation system 64, a firing
25 contact 62, and a first initiator charge 90. The ignitor tube translation system 64 includes an exterior tube 402 at least partially movably sheathed around an interior tube 404. Attached to the electronics module 9 is a safety sensor 80 and a pressure sensor 105. The main charge ignition 67 further includes a second initiator 70 and a candelabra ignitor 102. The safety sensor 80 is coupled to the electronics module 9 by wire 97. The pressure
30 sensor 105 is coupled to the electronics module 9. Similarly, the second initiator 70 is coupled to the electronics module by conductor 92.

integrated into the system to ensure that the first ignitor functions properly before the second ignitor is initiated. In one embodiment, a ring movement sensor coupled to the translator tubes opens a circuit in the electronics module after the projectile translates forward and separates the interlocking tubes. The open circuit serves as a signal to subsequently arm the second ignitor. A second embodiment consists of a simple plug which is shorted when attached to the rear of the projectile and is pulled from the projectile by the translation event, thereby opening the circuit.

Referring now to Figure 3, a schematic view of an example of a cartridge system constructed in accordance with the present invention in an initial cartridge configuration is shown. A projectile 50, with a cartridge having an electronic multi-pulse ignition system 60 is placed within a gun tube 40 prior to ignition of the first ignitor.

Referring now to Figure 4, an example of a cartridge system constructed in accordance with the present invention in a translational cartridge configuration is shown schematically. Figure 4 shows events after firing of the first ignitor charge 90. It can be seen that the projectile 50 is moving forward with respect to the initial position. In operation, as exterior tube 402 moves forward it separates from interior tube 404. Safety sensor 80, being also mechanically coupled to the ignitor tube translation system 64, then operates to send a movement sensor activation signal to the electronics module 9 to indicate whether or not it is safe to fire the second ignitor 70, as explained above with respect to the process flow diagram of Figure 1. At the same time, the pressure from firing the first ignitor charge 90 activates a signal in an optional pressure sensor 105 indicating that it is safe to trigger the second initiator 70 for firing the main charge ignition system 67.

Referring now to Figure 5, a schematic view of one example of a cartridge system constructed in accordance with the present invention in a cartridge configuration after main charge ignition is shown. As shown in Figure 5, the cartridge is launched by firing of the main charge ignition system as indicated generally by flame indicators shown as shading 500. In accordance with this example of the invention, the main charge ignition system is not lit until after a count down period after firing of the first initiator.

Referring now to Figure 6, a graphical comparison of one example of performance of a cartridge system constructed in accordance with the present invention against a conventionally ignited cartridge is shown. The Figure 6 graph includes a first vertical axis

610, second vertical axis 612 and a horizontal axis 614. Also shown are a first curve plotted curve 602 and second plotted curve 604. The first vertical axis 610 indicates muzzle velocity in meters per second for a first cartridge, namely, model TERM-KE. The second vertical axis 612 indicates muzzle velocity in meters per second for a second cartridge, namely, model M829A2.

The TERM-KE cartridge, plotted on curve 602, incorporates the electronic multi-pulse ignition system of the invention, and the M829A2 cartridge, plotted on curve 604, is a conventional ignition system typical of high performance 120mm tank ammunition. Horizontal axis 614 indicates test temperatures in degrees Fahrenheit. Note that test data for temperatures between -25 degrees F and + 120 degrees F shows the TERM-KE cartridge maintained essentially the same muzzle velocity while the conventional M829A2 cartridge showed a drop of over 10% in muzzle velocity as the temperature diminishes.

What is claimed is:

Claims

1. An electronically controlled multi-pulse ignitor for a cartridge constructed to launch a projectile comprising:
 - (a) an electronics module programmed with a temperature performance profile for the cartridge;
 - (b) a temperature sensor coupled to supply current cartridge temperature data to the electronics module;
 - (c) a first event ignitor, coupled to the electronics module, for initiating a ballistic cycle upon command from the electronics module;
 - (d) a translation mechanism, including a first charge coupled to the first event ignitor, for moving the projectile forward to increase the free volume in the cartridge; and
 - (e) a second event ignitor, coupled to receive a second event ignition signal from the electronics module, for igniting the main propellant charge on receiving the second event ignition signal from the electronics module, wherein the timing of ignition of the second event ignitor is determined by the temperature performance profile and the current cartridge temperature data.
2. The electronically controlled multi-pulse ignitor of claim 1 further comprising a safety sensor for arming the second event timer only upon a determination of safe firing conditions.
3. The electronically controlled multi-pulse ignitor of claim 2 wherein the safety sensor senses movement of the projectile.
4. The electronically controlled multi-pulse ignitor of claim 2 wherein the safety sensor senses pressure.
5. The electronically controlled multi-pulse ignitor of claim 1 further comprising:
 - (a) a first safety sensor, coupled to the electronics module, for sensing movement; and
 - (b) a second first safety sensor, coupled to the electronics module, for sensing pressure.

6. The electronically controlled multi-pulse ignitor of claim 1 wherein the translation mechanism further comprises two interlocking tubes containing a small propellant charge.
- 5 7. The electronically controlled multi-pulse ignitor of claim 1 wherein the translation mechanism includes means for moving the projectile forward.
8. The electronically controlled multi-pulse ignitor of claim 1 wherein the electronics module is armed by an electrical firing pulse of a gun system.
- 10 9. The electronically controlled multi-pulse ignitor of claim 1 wherein the electronics module is armed by the firing pin of a percussion gun activating the circuitry.
- 15 10. A method for igniting a cartridge to launch a projectile using a first initiator and a second initiator, wherein the cartridge has a temperature performance profile, comprising the steps of:
- (a) receiving an initiation signal;
 - (b) reading a current temperature in the cartridge;
 - (c) determining a delay setting from the current temperature and the temperature performance profile;
 - 20 (d) initiating an event timer;
 - (e) firing the first initiator to trigger a translation mechanism to start the projectile moving forward;
 - (f) commencing a second event countdown after the projectile has moved a
 - 25 predetermined distance; and
 - (g) arming the second initiator when the countdown is complete.
11. The method of claim 10 wherein the step of receiving an initiation signal further comprises receiving an initiation signal for an electrically fired cartridge.

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12. The method of claim 10 wherein the step of receiving an initiation signal further comprises receiving an initiation signal from a firing pin for a percussion fired cartridge.

5 13. The method of claim 10 wherein the step of commencing a second event countdown further comprises determining whether pressure conditions meeting a predetermined safety criterion are present in the cartridge before firing the second initiator, otherwise aborting arming the second initiator.

10 14. The method of claim 10 wherein the step of commencing a second event countdown further comprises determining whether forward movement of the projectile satisfy a predetermined safety criterion before firing the second initiator.

15 15. The method of claim 10 wherein the step of commencing a second event countdown further comprises the steps of:

- (a) determining whether pressure conditions meeting a predetermined safety criterion are present in the cartridge before firing the second initiator; and
- (b) determining whether forward movement of the projectile satisfy a predetermined safety criterion before firing the second initiator.

20 16. A method for igniting a cartridge to launch a projectile using a first initiator and a second initiator in communication with a movement and/or pressure safety switch, wherein the cartridge has a temperature performance profile, comprising the steps of:

- (a) storing the temperature profile in the electronics module;
- 25 (b) receiving an initiation signal;
- (c) reading a current temperature in the cartridge into the electronics module;
- (d) operating the electronics module to determine a dual event delay setting from the current temperature and the temperature performance profile;
- (e) initiating an event timer to time the dual event delay;
- 30 (f) firing the first initiator to trigger a translation mechanism to start the projectile moving forward;
- (g) commencing a second event after a countdown; and

(h) arming the second initiator when the countdown is complete, and the movement and/or pressure safety switch has activated, to light the main gun propellant.

17. The method of claim 16 wherein the step of receiving an initiation signal further
5 comprises receiving an initiation signal for an electrically fired cartridge.

18. The method of claim 16 wherein the step of receiving an initiation signal further
comprises receiving an initiation signal from a firing pin for a percussion fired
cartridge.

19. The method of claim 16 wherein the step of initiating a second event after a
countdown further comprises determining whether pressure conditions meeting a
predetermined safety criterion are present in the cartridge before initiating the second
event countdown, otherwise aborting arming the second initiator.

20. The method of claim 16 wherein the step of initiating a second event after a
countdown further comprises determining whether forward movement of the projectile
satisfy a predetermined safety criterion before initiating the second event, otherwise
aborting arming the second initiator.

MULTIPLE PULSE CARTRIDGE IGNITION SYSTEM

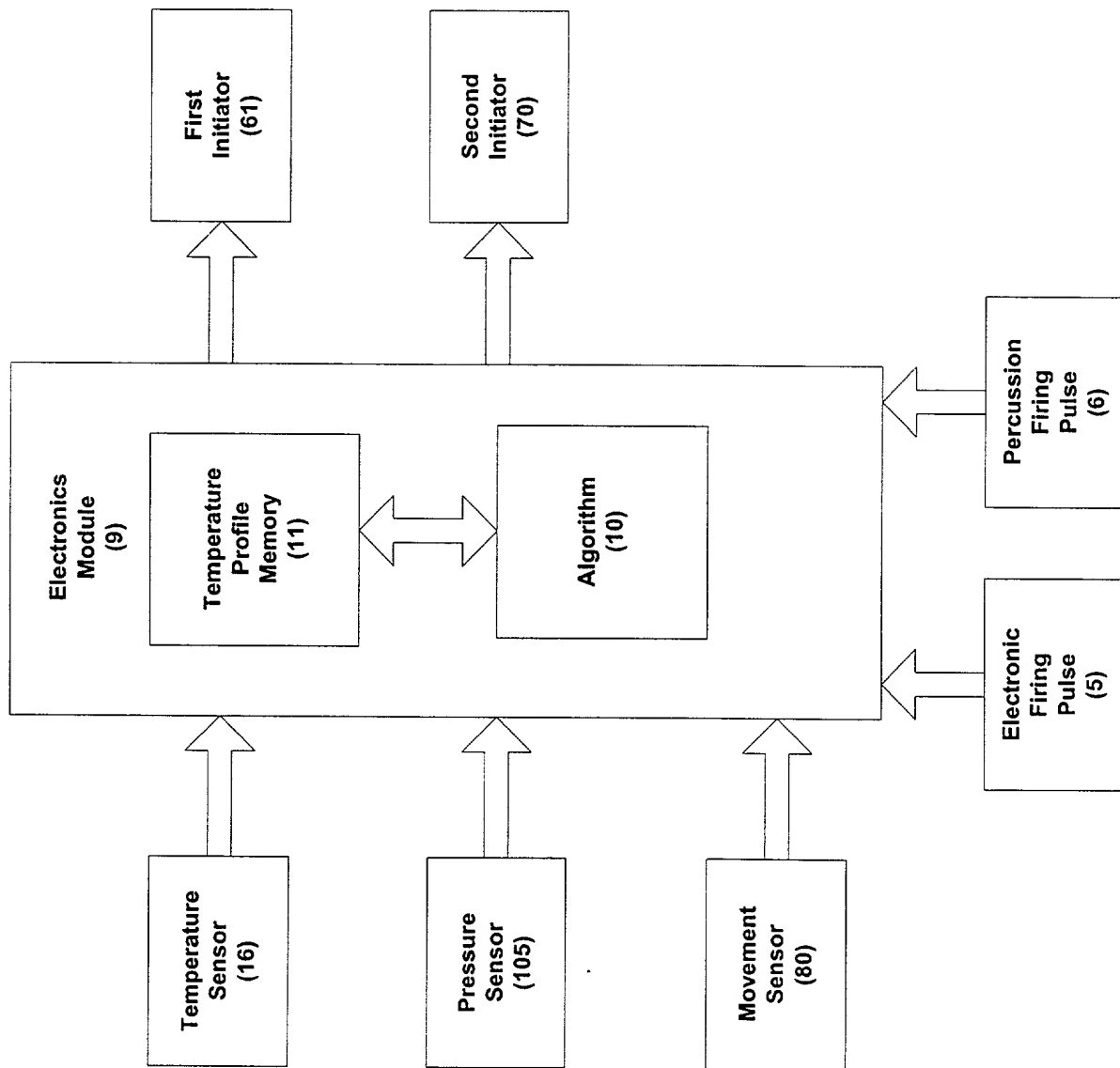
Abstract of the Disclosure

5 An electronically controlled multi-pulse ignitor ignites a cartridge used to launch a projectile. An electronics module is programmed with a temperature performance profile for the cartridge. A temperature sensor is coupled to supply current cartridge temperature data to the electronics module. A first event ignitor is coupled to the electronics module and initiates a ballistic cycle upon command from the electronics module. A translation mechanism, including a first charge coupled to the first event ignitor, moves the projectile
10 forward to increase the free volume in the cartridge. A second event ignitor, coupled to receive a second event ignition signal from the electronics module, ignites the main propellant charge on receiving the second event ignition signal from the electronics module, where the timing of ignition of the second event ignitor is determined by the temperature performance profile and the current cartridge temperature data.

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Figure 1A



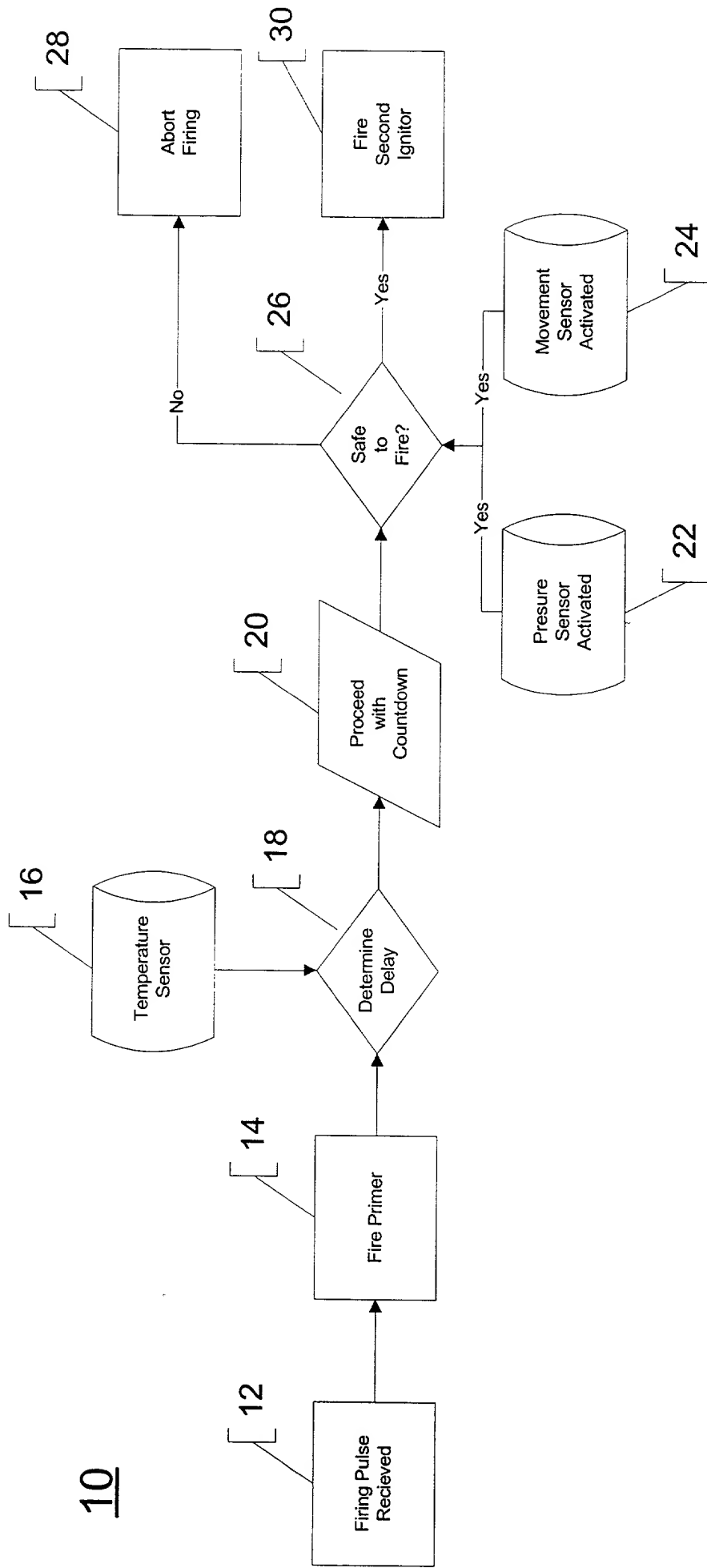


Figure 1B

Figure 2

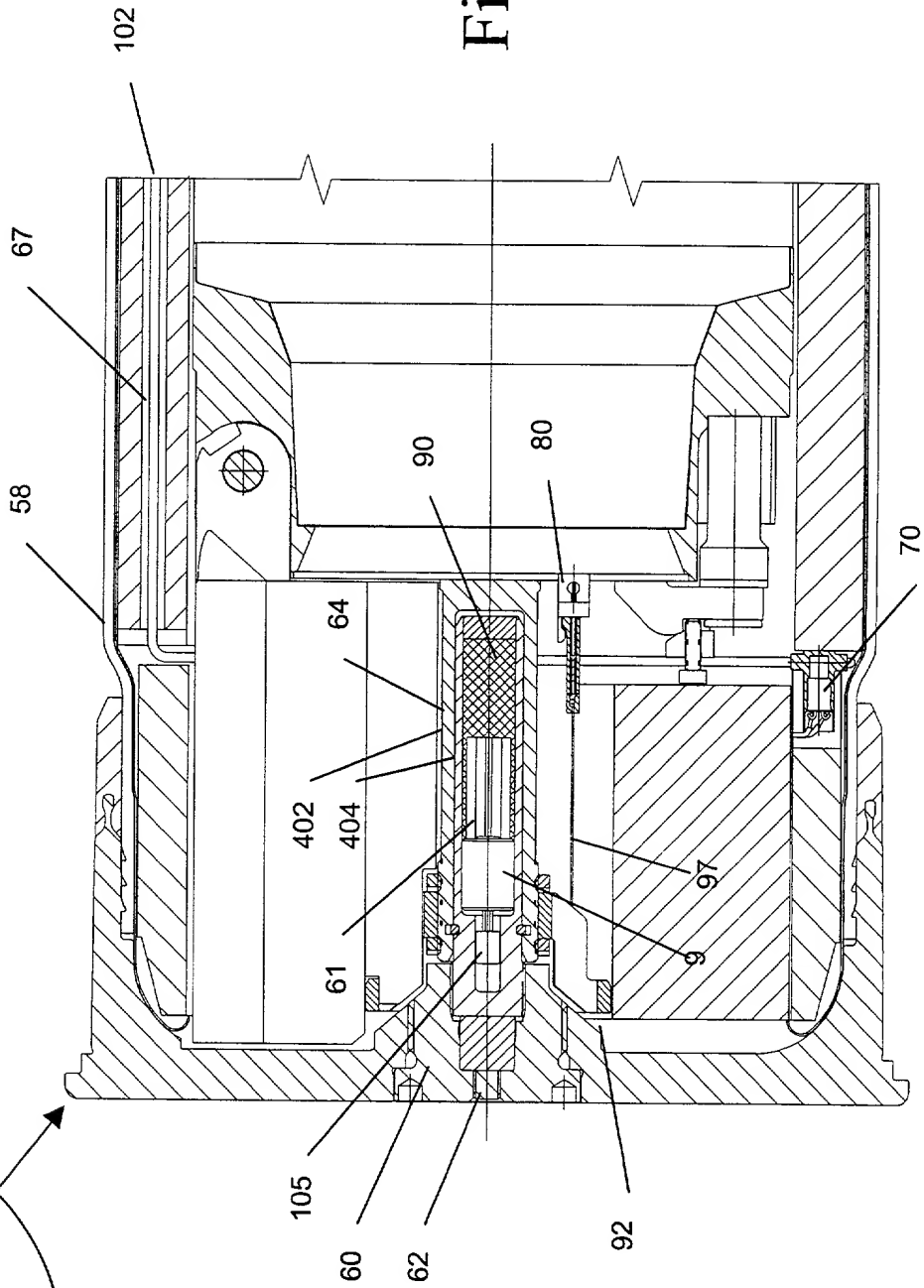
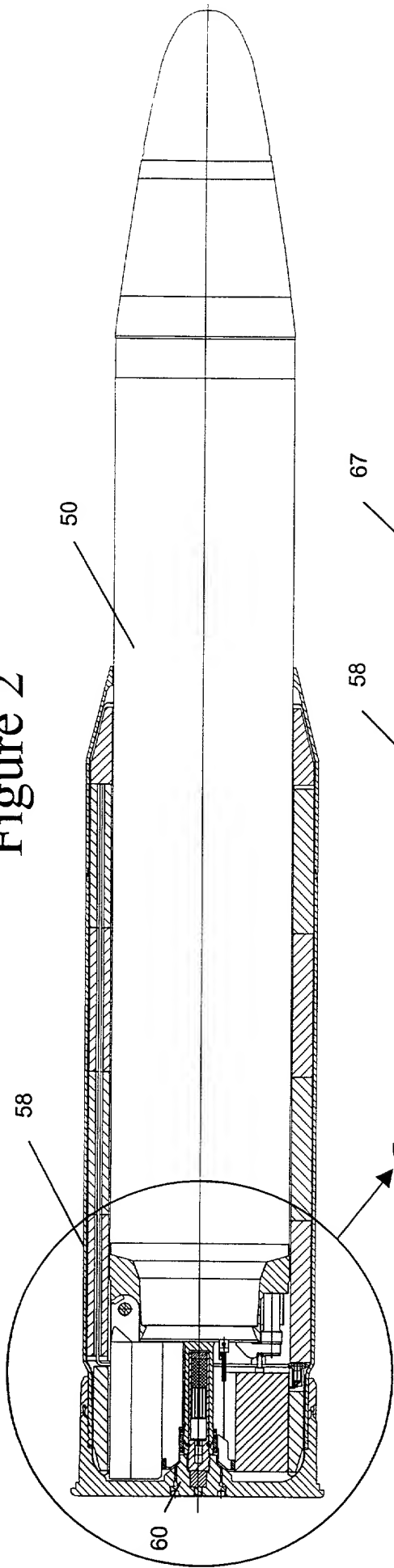


Figure 2A

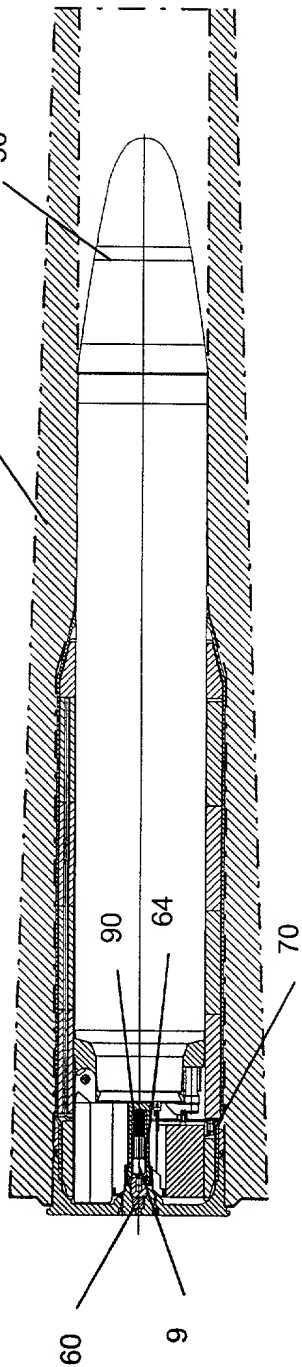


Figure 3

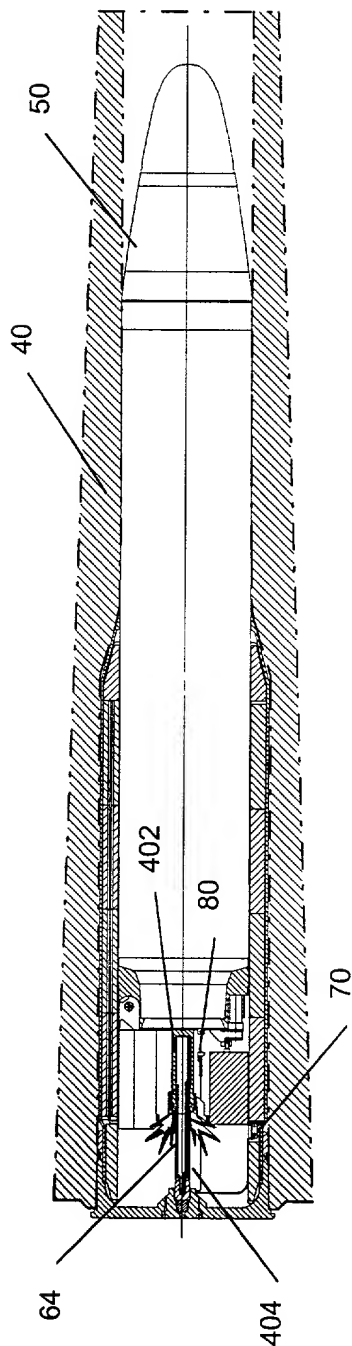


Figure 4

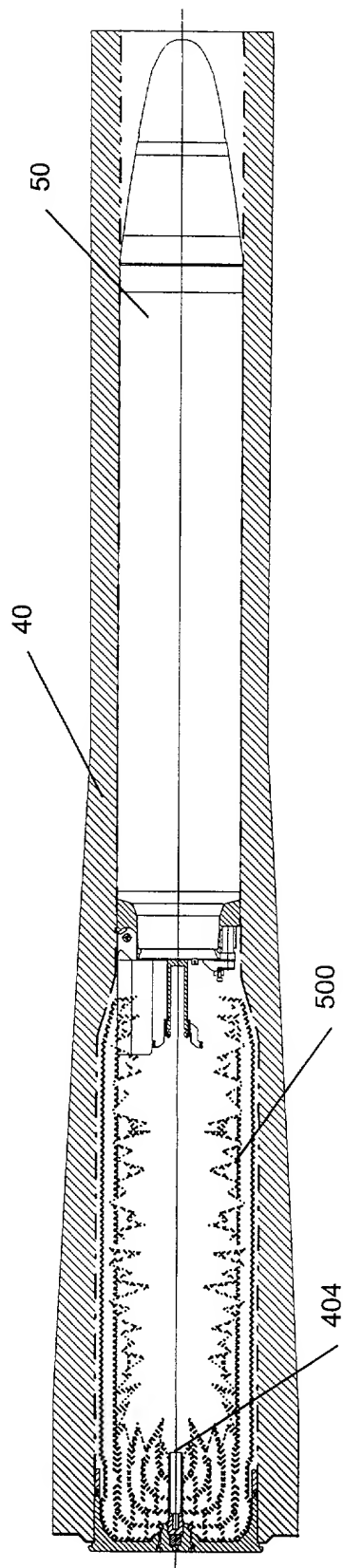


Figure 5

TERM-KE Smart Cartridge Performance over Temperature

120mm Gun Testing

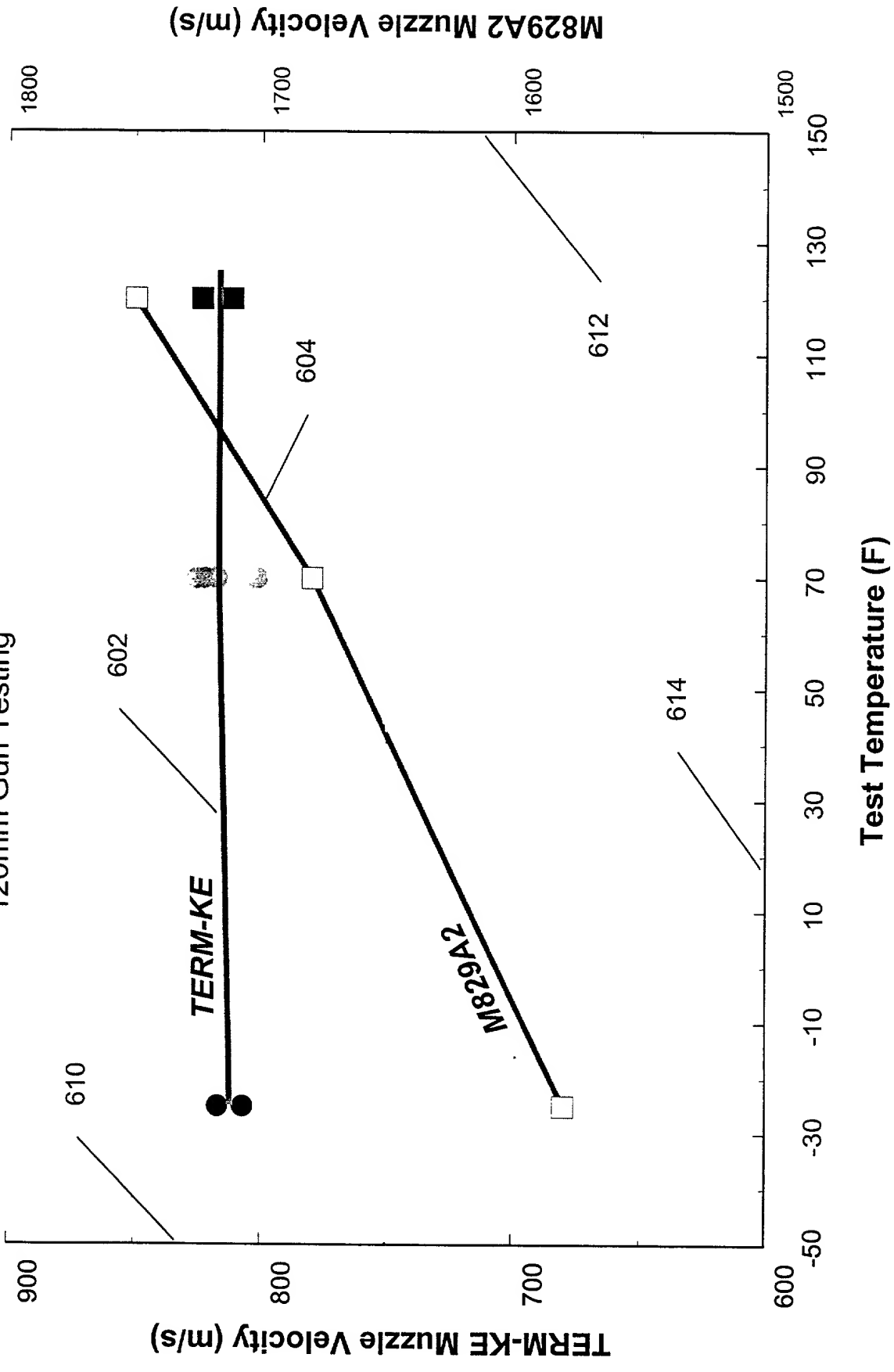


Figure 6

Docket No.
ATK20582

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MULTIPLE PULSE CARTRIDGE IGNITION SYSTEM

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____ and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

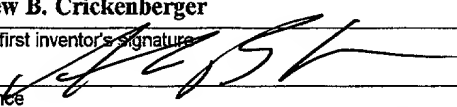
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

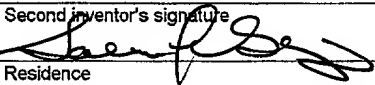
GeorgeA. Leone, Sr. (Reg. No. 30,567)

Mark Goldberg (Reg. No. 29,921)

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Sole or first inventor's signature 	Date JAN-13-2000
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Citizenship US	
Post Office Address 2 Pine Street P.O. Box 1004 Fort Ashby, West Virginia 26719	

Full name of second inventor, if any Saleem L. Ghazi	
Second inventor's signature 	Date JAN 27, 2000
Residence 2523 Black River Road Bethlehem, Pennsylvania 18015	
Citizenship US	
Post Office Address 2523 Black River Road Bethlehem, Pennsylvania 18015	